Q.P. Code : 50533

(3 Hours) [Total Marks : 80

N.B. (1) Question no. **1** is **compulsory.**
(2) Attempt any **three** questions out of remaining **five** questions.
(3) **Illustrate** your answer with **necessary** sketch wherever **necessary**.
(4) **Figures** to the **right** indicate full **marks**.

1. Attempt any FOUR of the following : **(20)**

(a) Explain types of chips produced during machining process.

Ans. Four Basic Types of Chip in Machining

1. Discontinuous chip
2. Continuous chip
3. Continuous chip with Built-up Edge (BUE)
4. Serrated chip

Segmented Chip

- Brittle work materials (e.g., cast irons)
- Low cutting speeds
- Large feed and depth of cut
- High tool-chip friction

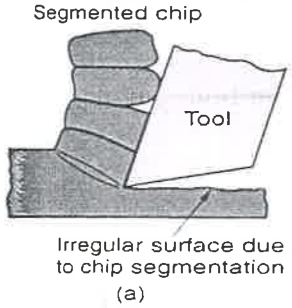


Figure - Four types of chip formation in metal cutting: (a) segmented

Continuous Chip

- Ductile work materials (e.g., low carbon steel)
- High cutting speeds
- Small feeds and depths
- Sharp cutting edge on the tool
- Low tool-chip friction

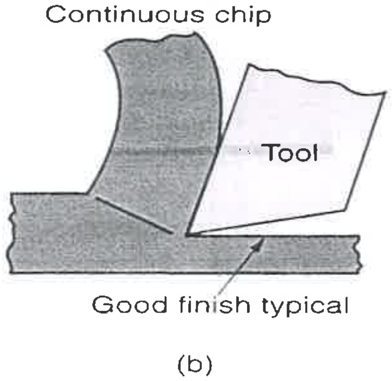


Figure - Four types of chip formation in metal cutting: (b) continuous

Continuous with BUE

- Ductile materials

- Low-to-medium cutting speeds
- Tool-chip friction causes portions of chip to adhere to rake face
- BUE formation is cyclical; it forms, then breaks off

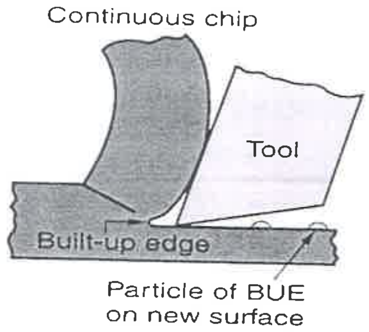
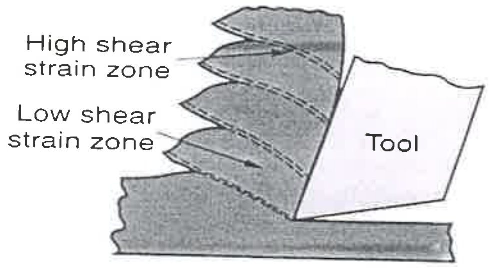


Figure - Four types of chip formation in metal cutting: (c) continuous with built-up edge

Serrated Chip

- Semicontinuous - saw-tooth appearance
- Cyclical chip formation of alternating high shear strain then low shear strain
- Most closely associated with difficult-to-machine metals at high cutting speeds



(d)

Figure - Four types of chip formation in metal cutting: (d) serrated

(b) Explain machinability.

Ans. Machinability of a material indicates how machinable the material is.

The parameters which affect the machinability are:

Physical and mechanical properties of a material

Chemical composition and microstructure of a material.

Cutting conditions.

The general criteria for evaluating machinability are as follows.

Tool life:

Longer tool life at given cutting speed indicates better machinability

Surface finish:

Better the surface finish higher is the machinability.

Power consumption:

If for metal removal power consumption is low then it indicates better machinability.

Cutting force:

Lesser the cutting force for removing higher volume of metal, higher will be the machinabilty.

Shear index:

Larger shear angle gives better machinability.

(c) Distinguish between Additive Manufacturing (AM) and CNC machining.

Ans. :

	Parameter	AM Machining	CNC machining
1	Material	Developed around polymeric materials, waxes and paper laminates.	Can be used for soft materials like medium density, fibreboard, machinable foams, machinable waxes etc.
2	Speed	To make part by AM it may take few hours	It would take week to develop same part
3	Complexity	AM machines are generally complex and due to complexity they are more efficient	CNC machines are not complex hence they have less efficiency
4	Accuracy	Due to its variable resolution along different orthogonal axes AM is more accurate as compared to CNC	Due to limited resolution along only 3 orthogonal axes CNC machines are not that accurate

(d) Compare milling fixture and drilling fixture.

Ans. :

Sr. No.	Milling Fixture	Drilling Fixture
1	Milling fixture can easily be fitted into T slots of the machine table.	Drilling fixture cannot be fitted into T slots of the machine table.
2	It is heavy in construction.	It is light in construction.
3	Workpiece is directly held in the fixture.	Workpiece should have previously machined bore.
4	Setting block and feeler gauges are used to set workpiece correctly with cutter.	Drilling bushes are used to set the workpiece in correct relationship with drill.
5	The clamping method can cause distortion in workpiece.	The clamping method does not cause distortion in workpiece.

(e) Explain scrap strip layout.

Ans. In the blanking die design, the first strip is to prepare blanking layout, i.e; the position of the workpieces in the strip and their orientation with respect to each other. This is called as strip layout. Following are the factors which affect the strip layout:

Economy of the material

Direction of material gain

Burr direction
Press used
Die cost.
Production required.

2. (a) Define tool life and explain factors affecting tool life (10)

Ans. Tool life – length of cutting time that a tool can be used

Factors affecting tool life:

Cutting speed:

It is a major factor affecting tool life. It varies inversely with tool life. It leads to the generation of parabolic curve.

$VT^n = C$

V = Cutting speed in m/min
T = Tool life in minutes
n = Tool life index
C = machining constant

Feed and depth of cut:

Inversely proportional to the tool life.

Tool geometry:

Geometrical parameters of the cutting tool (tool angle) affect the tool performance and tool life.

Tool material:

Tool material which can withstand maximum cutting temperature without losing its mechanical properties and geometry will ensure maximum tool life.

Work materials:

Higher the hardness of work materials greater will be the tool wear and hence shorter will be the tool life.

Nature of cutting:

Tool life is also affected by nature of cutting; whether it is continuous or intermittent.

Rigidity of machine tool and work:

Machine tool and work piece both should remain rigid while machining operation. If they are not rigid then vibrations are developed.

Cutting fluids:

Cutting fluid reduces the heat between the tool and work, reduces friction, improves surface finish and helps in chip breaking and washing away.

(b) Write in detail about indexing devices. (6)

Ans. Indexing in jigs and fixtures uses a simple indexing plate for their operations.

Consider a flange in which six holes are to be drilled, which is mounted on an index plate which has six equi spaced slots.

Under the drill, the workpiece is revolved and each hole is drilled in turn.

For this purpose an index plunger is used, which fits by turn in every slot in the index plate.

For indexing the workpiece the plunger is pulled out of the slot.

The index plate and thereby the workpiece is rotated, until next slot comes in line of the index plunger.

The arrangement using sliding device is shown.

The sliding member consists of a slot in suitable spacing and a fixed member

consisting a spring loaded lever which fits into the slots.
For indexing, the lever is lifted off a slot and sliding member is moved until the next slot comes under the lever.

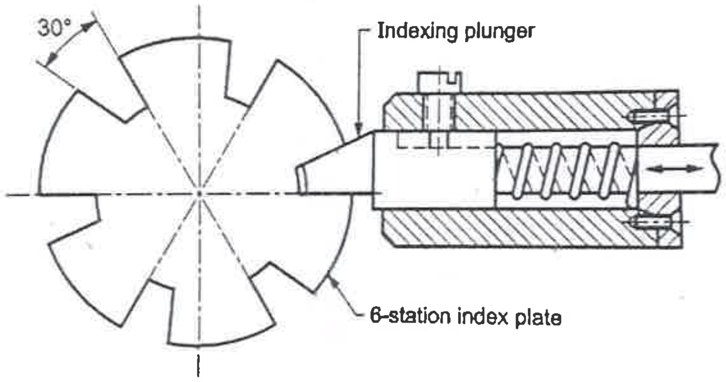


Fig Indexing plate

(c) Explain in detail about powder bed fusion. **(4)**

Ans. This method uses laser or electron beam to melt and fuse material powder together.
In this process, powder is spread over the previous layer of powder.
A laser fuses the first layer of the model.
The new layer is spread across the previous layer using a roller.
Further layers are also fused and added.
This process is repeated until the whole model is ready.
Then by post processing loose powder is removed.
A happer below the workpiece helps to supply the fresh material.
A platform is provided to lower the model as per the requirement.

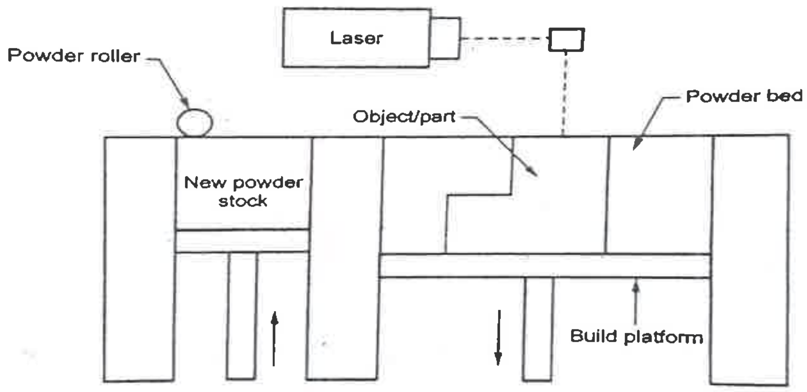


Fig. Powder based fusion

3. (a) State the classification of AM(Additive Manufacturing) / RP (Rapid Prototyping) systems and explain any one in detail. **(10)**

Ans. There are different ways to classify AM technology. A popular ay is to classify as per the baseline technology i.e; whether the process uses lasers, printer technology or extrusion technology.
Another way of classification is as per the type of raw material used.
Generally AM/RP systems are classified as follows:
Liquid polymer systems:

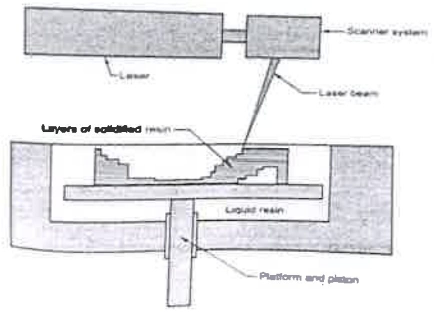


Fig. Liquid polymer system

Discrete particle systems:

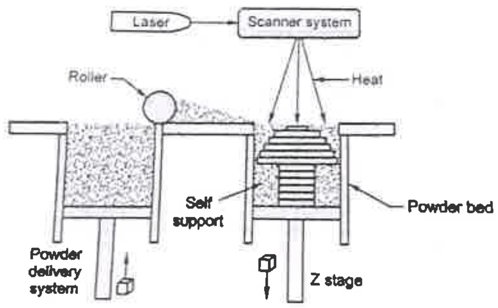


Fig. Discrete particle system

Molten materials systems:

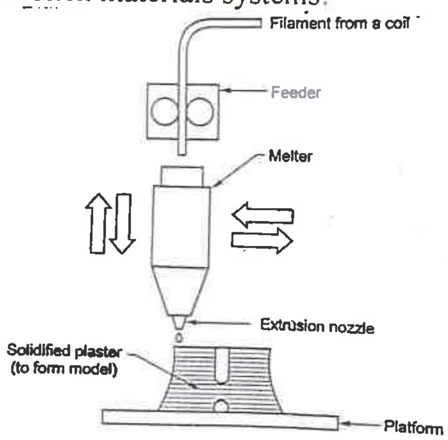
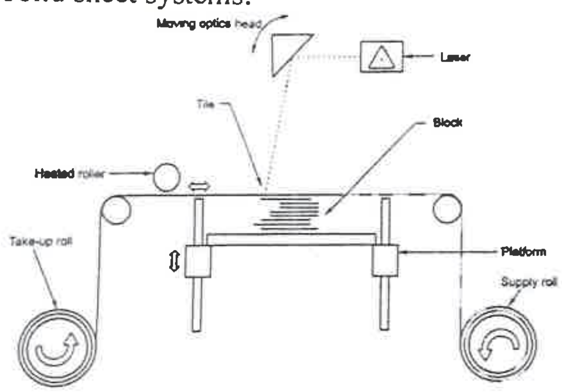


Fig. Fused deposition modeling

Solid sheet systems:



(b) List different types of dynamometers and explain strain gauge type dynamometer. **(6)**

Ans. Dynamometer is a device used in metal cutting or machining operation for determination of cutting forces.

The various types of dynamometers are:

Mechanical dynamometers

Hydraulic and Pneumatic dynamometers

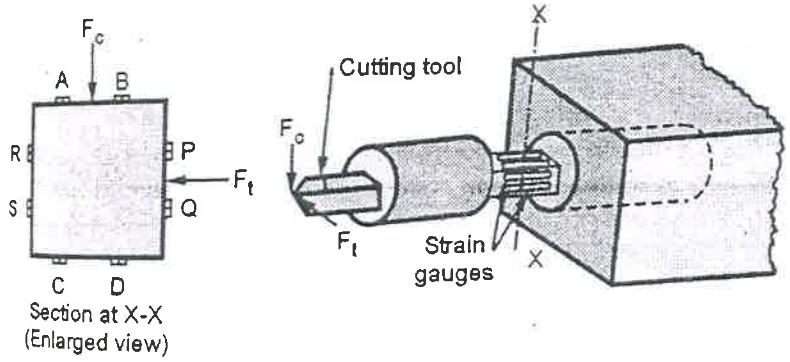
Piezoelectric dynamometers

Electrical dynamometers

Strain gauge type dynamometer:

Also called as turning dynamometer.

This type of gauges are widely used because mechanical methods for measuring strains are not very reliable.



(c) Explain end milling cutters in detail. **(4)**

Ans. End milling cutters have cutting teeth on the end as ewll as on the circumference of the cutter.

The teeth on circumference may be straight or helical and the helix may be left hand or right hand.

These cutters are used for light milling operations as cutting slots, machining accurate holes, profile milling, narrow flat surfaces etc.

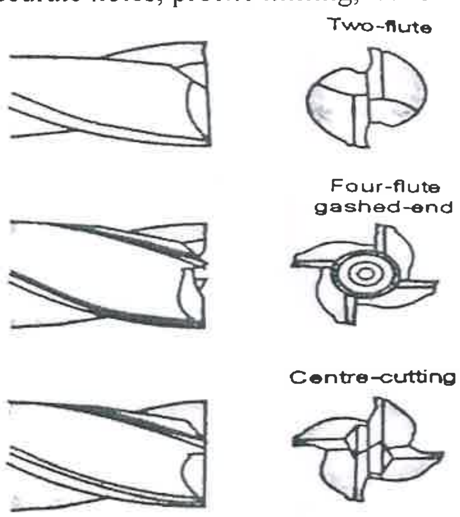
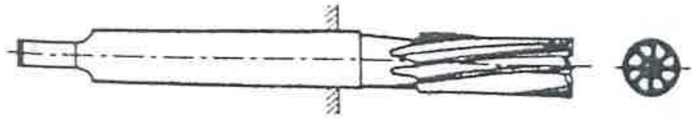


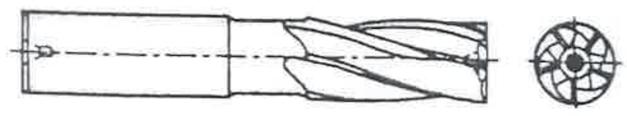
Fig. Types of end teeth

The different types of end milling cutters are:

Taper shank end milling cutters:

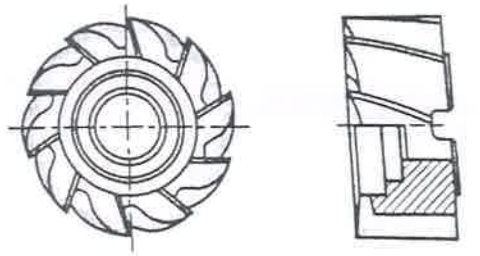


(a) Taper shank end mill



(b) Straight shank end mill

Straight shank end milling cutters:



(c) Shell end milling cutter

Shell end milling cutters:

4. **(a)** Describe the mechanism of chip formation in detail. **(10)**

Ans. Orthogonal cutting

Chip Formation by Shearing

- The tool has a rake angle of α , and a relief (clearance) angle.
- The shearing process in chip formation is similar to the motion of cards in a deck sliding against each other.

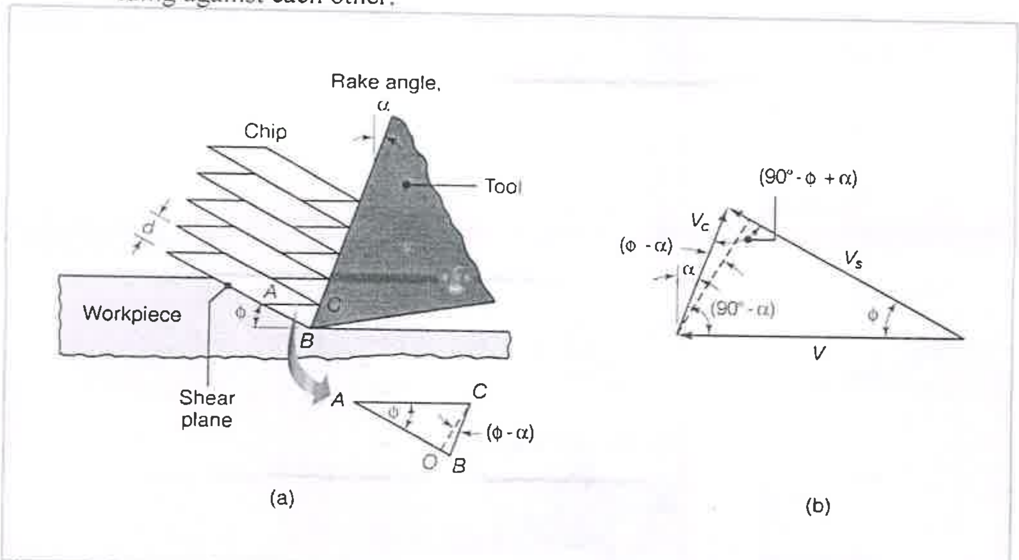


Figure (a) Schematic illustration of the basic mechanism of chip formation by shearing. (b) Velocity diagram showing angular relationships among the three speeds in the cutting zone.

THE MECHANICS OF CHIP FORMATION- ORTHOGONAL CUTTING

- The ratio of t_o/t_c is known as the cutting ratio, r, expressed as:

$$r = \frac{t_o}{t_c} = \frac{\sin\phi}{\cos(\phi-\alpha)} < 1$$

- Chip thickness is always greater than the depth of cut
- Chip compression ratio: reciprocal of r. It is a measure of how thick the chip has become compared to the depth of cut.
- The cutting ratio is an important and useful parameter for evaluating cutting conditions. Since the undeformed chip thickness, t_o, is a machine setting and is therefore known, the cutting ratio can be calculated easily by measuring the chip thickness with a micrometer.

THE MECHANICS OF CHIP FORMATION- ORTHOGONAL CUTTING

The shear strain, γ, that the material undergoes can be express as:

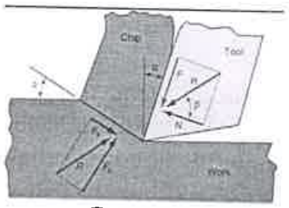
$$\gamma = \frac{AB}{OC} = \frac{AO}{OC} + \frac{OB}{OC} = \cot\phi + \tan(\phi - \alpha)$$

Large shear strains are associated with low shear angles, or low or negative rake angles.
Shear strains of 5 or higher in actual cutting operations.
Deformation in cutting generally takes place within a very narrow deformation zone; that is, d = OC in Fig.. is very small.
Therefore, the rate at which shearing takes place is high.
Shear angle influences force and power requirements, chip thickness, and temperature.
Consequently, much attention has been focused on determining the relationships between the shear angle and workpiece material properties and cutting process variables.
Assuming that the shear angle adjusts itself to minimize the cutting force, or that the shear plane is a plane of maximum shear stress.

$$\phi = 45^\circ + \frac{\alpha}{2} - \frac{\beta}{2}$$

β is the friction angle and is related to the coefficient of friction, μ, at the tool – chip interface (rake face):

$$\mu = \tan\beta$$



- From Eq as the rake angle decreases and / or the friction at the tool – chip interface increases, the shear angle decreases and the chip becomes thicker,
- Thicker chips mean more energy dissipation because the shear strain is higher
- Because work done during cutting is converted into heat, temperature rise is also higher.
- Higher shear plane angle means smaller shear plane which means lower shear force

Result: lower cutting forces, power, temperature, all of which mean easier machining

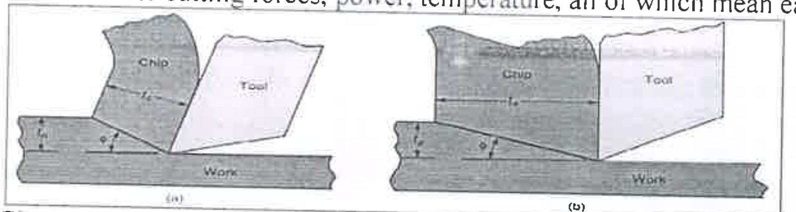


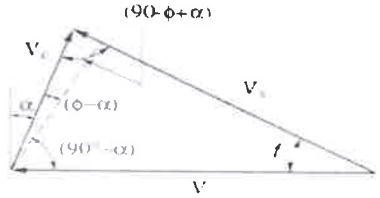
Figure - Effect of shear plane angle Ø: (a) higher Ø with a resulting lower shear plane area; (b) smaller Ø with a corresponding larger shear plane area. Note that the rake angle is larger in (a), which tends to increase shear angle according to the Merchant equation
From Fig., since chip thickness is greater than the depth of cut, the velocity of the chip, V_c, has to be lower than the cutting speed, V.

Conservation of mass:

$$V t_o = V_c t_c, \qquad V_c = rV = \frac{V \sin\phi}{\cos(\phi - \alpha)}$$

From the velocity diagram (Fig. 20.4b), we obtain the

$$\frac{V}{\cos(\phi - \alpha)} = \frac{V_s}{\cos\alpha} = \frac{V_c}{\sin\phi}$$



V_s is the velocity at which shearing takes place in the shear plane.

Chip Thickness Ratio $r = \frac{t_o}{t_c}$

where r = chip thickness ratio; t_o = thickness of the chip prior to chip formation; and t_c = chip thickness after separation

- Chip thickness after cut is always greater than before, so chip ratio is always less than 1.0

Determining Shear Plane Angle

- Based on the geometric parameters of the orthogonal model, the shear plane angle ϕ can be determined as: $\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha}$

where r = chip ratio, and α = rake angle

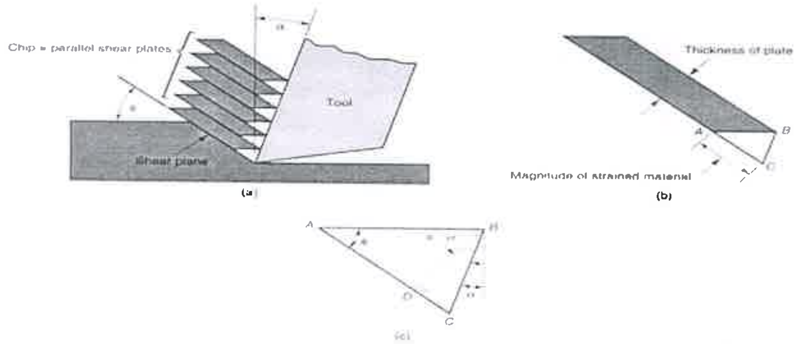


Figure - Shear strain during chip formation: (a) chip formation depicted as a series of parallel plates sliding relative to each other, (b) one of the plates isolated to show shear strain, and (c) shear strain triangle used to derive strain equation

Shear Strain

Shear strain in machining can be computed from the following equation, based on the preceding parallel plate model:

$\gamma = \tan(\phi - \alpha) + \cot\phi$

where γ = shear strain, ϕ = shear plane angle, and α = rake angle of cutting tool

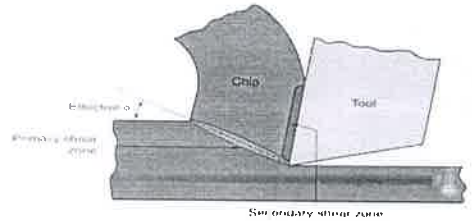


Figure - More realistic view of chip formation, showing shear zone rather than shear plane. Also shown is the secondary shear zone resulting from tool-chip friction

The Merchant Equation

- Of all the possible angles at which shear deformation could occur, the work material will select a shear plane angle ϕ which minimizes energy, given by

- Derived by Eugene Merchant $\phi = 45 + \frac{\alpha}{2} - \frac{\beta}{2}$
- Based on orthogonal cutting, but validity extends to 3-D machining
- Higher shear plane angle means smaller shear plane which means lower shear force
- Result: lower cutting forces, power, temperature, all of which mean easier machining

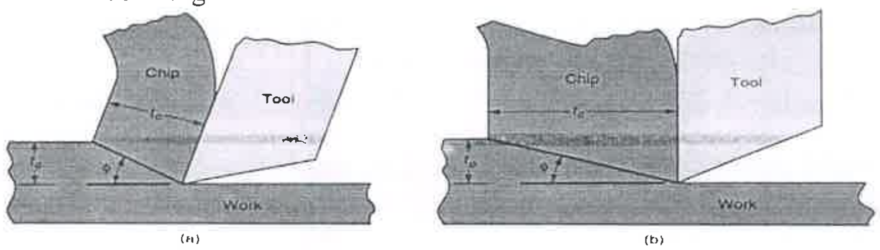


Figure - Effect of shear plane angleϕ : (a) higher ϕ with a resulting lower shear plane area; (b) smaller ϕ with a corresponding larger shear plane area. Note that the rake angle is larger in (a), which tends to increase shear angle according to the Merchant equation

(b) Explain the steps in designing bending dies. **(6)**

Ans. Bending is the process in which a straight length is transformed into a curved length.

During bending, the outer surface of the material is in tension and inner surface is in compression.

The strain in the bent material increases with decreasing curvature radius.

Bend Radius:

Is the radius of curvature on inside surface of the end.

If the end is too small then cracking of the material on the outer tensile surface takes place.

Bend allowance:

To calculate blank length for bending, the length of the material in the curved section has to be calculated.

The length of the bend area which is more than blank length before bending is known as bend allowance.

Bending pressure or bending force:

It depends on the stock thickness, bend length, die opening width and type of bend.

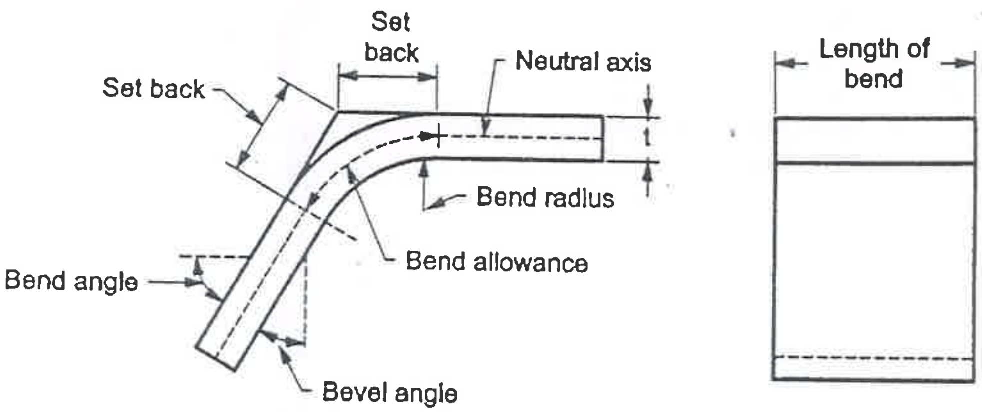


Fig. Bending terminology

(c) Explain the design principles for turning fixtures. **(4)**

Ans. Turning fixture should be perfectly balanced and light in weight to reduce vibrations, as it is revolving with the workpiece.

The size of fixture should be small enough that it should not hit the bed.

The turning fixture should be designed properly so that it should not obstruct the turning operation.

The clamping devices for fixture clamping should design to overcome centrifugal force. Fixture should not get loose while rotating.

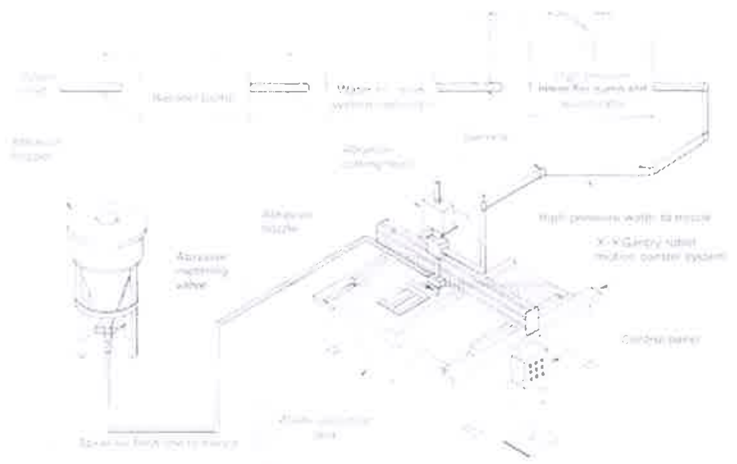
The turning fixture should have good rigidity and minimum overhang to avoid bending.

The extended parts or projections of fixture should not cause harm to the operator.

5. **(a)** Give the classification of non traditional machining processes and explain water jet machining in detail. **(10)**

Ans. The classification of NTM processes is carried out depending on the nature of energy used for material removal.

- or hydrodynamic machining,
- uses a high-velocity fluid jet impinging on the workpiece to perform a slitting operation (Figure).
- Water is ejected from a nozzle orifice at high pressure (up to 60,000 psi).
- The jet is typically 0.076 to 0.5 mm in diameter and exits the orifice at velocities up to 900 m/sec.
- Key process parameters include water pressure, orifice diameter, water flow rate, and working distance (distance between the workpiece and the nozzle).
- Nozzle materials include synthetic sapphire due to its machinability and resistance to wear.
- Tool life on the order of several hundred hours is typical. Mechanisms for tool failure include chipping from contaminants or constriction due to mineral deposits.
- This emphasizes the need for high levels of filtration prior to pressure intensification.



(b) Estimate the blanking force to cut a blank of 20 mm wide and 30 mm long from a 1.2 mm thick metal strip. If the ultimate shearing strength of the material is 450 N/mm^2, also find the work done if the percentage penetration is 30% of the thickness. **(6)**

Ans. Given data :

$b = 20$ mm
$L = 30$ mm
$t = 1.2$ mm
$\tau_s = 450\ N/mm^2$
$K = 0.3$

Blanking force (F_b) for a rectangular workpiece is given by,

$F_b = 2\,(L + b) \times t \times \tau_s$
$= 2\,(30+20) \times 1.2 \times 450 = 54$ kN

Work done = F x punch travel = F x K x t = 54000 x 0.3 x 1.2 = 19.44 Nm

(c) Differentiate between orthogonal and oblique cutting. **(4)**

Ans. :

Sr. No.	Orthogonal cutting	Oblique cutting
1	The cutting edge of the tool remains normal to the cutting velocity direction.	The cutting edge of the tool is inclined at an acute angle with tool feed direction.
2	The direction of chip flow velocity is perpendicular to the edge of the tool.	The direction of chip flow velocity is at an angle with the normal to the cutting edge of the tool.
3	Inclination angle of the cutting edge of the tool normal to the cutting velocity is zero.	Tool cutting edge is inclined at an angle q with normal to the cutting velocity.
4	The cutting edge is longer than the width of the cut.	The cutting edge may or may not be longer than the width of the cut.
5	This type of cutting is called as two dimensional cutting.	This type of cutting is called as three dimensional cutting.
6	Tool life is less	More tool life.

6. Write short note on: **20**

(a) Factors affecting surface finish

Ans. Cutting speed:

It is defined as the rate at which cutting speed of the tool passes over the surface of the workpiece in unit time.

Feed:

The distance travelled y the tool along or into the workpiece, for each pass of tool point in unit time.

Depth of cut:

It is the penetration of the cutting edge of the tool into the material of the workpiece in each pass, measured perpendicular to the machine surface.

Metal removal rate:

It is defined as the volume of material removed in unit time.

(b) 3D Systems Sterelithography Apparatus (SLA)

Ans. Materials:

Different types of photo polymers are available which can be hardened when exposed to x-rays, gamma rays or UV light

Some of the materials are: Perform (ceramic based off white in colour), Next (polymer based white colour resin), 18420 protogen (polymer based liquid white colour).

Advantages:

Different SLA machines have built volumes ranging from small to large to suit the need of the users.

It can be used continuously without any supervision.

It has very good accuracy

Disadvantages:

In some cases SLA requires support structures that must be separately designed and fabricated.

After finishing the process, post processing is needed which is time consuming.

Applications:

Jigs and fixtures

Investment casting patterns

Threaded inserts and custom machined inserts.

(c) Types of coolants

Ans. Generally, cutting fluids are employed in liquid form but occasionally also employed in gaseous form. Only for lubricating purpose, often solid lubricants are also employed in machining and grinding. The cutting fluids, which are commonly used, are :

• Air blast or compressed air only. Machining of some materials like grey cast iron become inconvenient or difficult if any cutting fluid is employed in liquid form. In such case only air blast is recommended for cooling and cleaning

• Water For its good wetting and spreading properties and very high specific heat, water is considered as the best coolant and hence employed where cooling is most urgent.

• Soluble oil Water acts as the best coolant but does not lubricate. Besides, use of only water may impair the machine-fixture-tool-work system by rusting So oil containing some emulsifying agent and additive like EPA, together called cutting compound, is mixed with water in a suitable ratio (1 ~ 2 in 20 ~ 50). This milk like white emulsion, called soluble oil, is very common and widely used in machining and grinding.

• Cutting oils Cutting oils are generally compounds of mineral oil to which are added desired type and amount of vegetable, animal or marine oils for improving spreading, wetting and lubricating properties. As and when required some EP additive is also mixed to .reduce friction, adhesion and BUE formation in heavy cuts.

• Chemical fluids These are occasionally used fluids which are water based where some organic and or inorganic materials are dissolved in water to enable desired cutting fluid action. There are two types of such cutting fluid; – Chemically inactive type – high cooling, anti-rusting and wetting but less lubricating – Active (surface) type – moderate cooling and lubricating.

• Solid or semi-solid lubricant Paste, waxes, soaps, graphite, Moly-disulphide (MoS2) may also often be used, either applied directly to the workpiece or as an impregnant in the tool to reduce friction and thus cutting forces, temperature and tool wear.

• Cryogenic cutting fluid Extremely cold (cryogenic) fluids (often in the form of gases) like liquid CO2 or N2 are used in some special cases for effective cooling without creating much environmental pollution and health hazards.

(d) Chemical machining

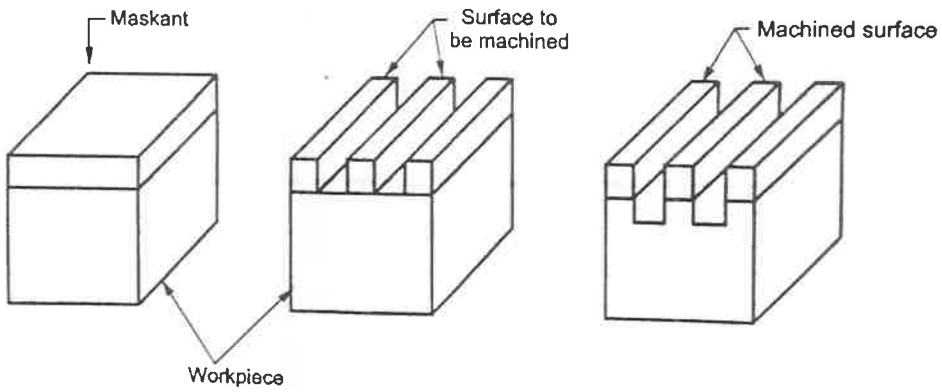
Ans. In this process by using chemical attack or etching material is removed from the workpiece.

The CM processes can be classified into following categories:

Chemical blanking

Chemical contour machining

Chemical engraving



(e) Balancing of grinding wheels

Ans. To obtain a good surface finish, to avoid vibration and to prevent undue wear on machine parts, it is necessary that grinding wheel should have good balance before its use.

Hence, the wheel is properly tested for balance, but before testing, it is trued

Balancing is done in the static position of the wheel by shifting the position of the eights on one of the flanges of the wheel.
The wheel is mounted on a suitable mandrel and is placed on a balancing fixture for finding out the direction in which the weights are to be shifted.

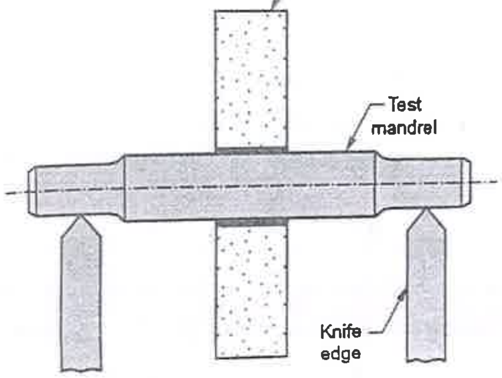


Fig. Balancing of grinding wheel

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